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Social determinants and diabetes mellitus type two morbidity in Saudi Arabia

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ABSTRACT

Aim: The present study aimed at exploring the social inequalities among type II Diabetes Miletus patients in Saudi Arabia, in addition to identifying the association of these factors. *Methods*: Cross-sectional studies over a sample of 574 male and female DM patients were recruited in this study. To collect data, the researchers adopted a valid and reliable translated version of a questionnaire that investigated the demographic characteristics of the DM patients and the comorbidities prevalent among them. Data were collected through planned phone calls with the patients. Descriptive statistics and multivariate linear regression were used to analyze the data collected from the participating DM patients. *Result*: The findings showed that the odds of having nephropathy was greater among females (OR 1.64, CI 95% 1.04-4.09), or divorced or widowed patients (OR 2.77, CI 95% 2.37-3.33), or patients with secondary school education or less (OR 1.84, CI 95% 1.45-3.16), In addition, the odds of having retinopathy was greater among females (OR 2.54, CI 95% 2.01-3.16), or married patients (OR 2.48, CI 95% 1.16-3.25), or patients with secondary school education or less (OR 3.12, CI 95% 1.63-7.19). Finally, it was found that the odds of having peripheral neuropathy was greater among females (OR 2.70, CI 95% 2.09-5.27), or married patients (OR 2.94, CI 95% 1.50-3.61. *Conclusion*: The study concluded that females, lower socioeconomic determinants such as lower educational level, unemployment, poor glycemic control, higher duration of DM were significantly associated with a higher prevalence of T2DM complications.

Keywords: Diabetes Mellitus, Type 2 Diabetes, Socio-economic inequalities, Morbidity, Saudi Arabia

1. INTRODUCTION

Diabetes mellitus is a group of metabolic diseases characterized by chronic high blood glucose levels, due to deficiency in insulin secretion, insulin action or both (World Health Organization, 2006). Type 2 diabetes mellitus (T2DM) one of the major types of Diabetes mellitus along with type 1 diabetes mellitus and gestational diabetes (Cho et al., 2018). Type 2 diabetes was classified as the most common type of diabetes, accounting for around 90% of all diabetes

cases (Saeedi et al., 2019). According to the International Diabetes Federation (IDF), Approximately 463 million adults (20-79 years) were living with diabetes worldwide; by 2045 this will rise to 700 million (Al-Daghri et al., 2011). Middle Eastern and North African (MENA) countries have a higher prevalence of DM compared to other regions in the world; the prevalence rate was 12.8% in 2017, and the rate is expected to increase to 15.7% by 2045 (Saeedi et al., 2019). In 2011, Al-Daghri et al., (2011) performed a cross-sectional study on 9149 participants and found a 31.6% prevalence rate of T2DM in Saudi Arabia.

In 2009, Alqurashi et al., (2011) performed a cross-sectional study done in Saudi Arabia to estimate the prevalence rate of T2DM and reported a prevalence rate for T2DM of 30%. People with diabetes have an increased risk of developing serious complications affecting the heart and blood vessels, eyes, kidneys, nerves and teeth (Al-Daghri et al., 2011). The complications of Diabetes can be classified into macrovascular complications, such as cardiovascular disease (CVD), and microvascular complications, such as Retinopathy, Nephropathy, and Neuropathy (World Health Organization, 2020). According to the IDF, Retinopathy defined as chronic hyperglycemia (high blood glucose), causing damage to retinal capillaries, leading to capillary leakage and blockage. It may lead to loss of vision and eventually blindness, nephropathy was defined as damage to small blood vessels in the kidneys leading to the kidneys becoming less functioning, and neuropathy defined as damage to the nerves throughout the body when blood glucose and blood pressure are too high. The most commonly affected areas are the extremities, which can lead to pain, tingling, and loss of sensation (Saeedi et al., 2019). Social determinants of health; known as conditions in social, physical, and economic status (Koh et al., 2011). According to the Centers for Disease Control and Prevention (CDC), a social determinant of health has an impact on the risks, and outcomes of health (Fielding et al., 2013).

Diabetes mellitus is rapidly increasing in both developing and developed countries (American Diabetes Association, 2014). It was reported in industrialized countries, the risk of developing diabetes and their chronic complications are linked to a low SES (Connolly et al., 1996; Whitford et al., 2003; Mindell et al., 2012). A cross-sectional questionnaire-based study was conducted in Southern Serbia, and they concluded that both socioeconomic and chronic complications are relevant factors (Stojanović et al., 2018). Another cross-sectional study done in Trinidad and Tobago, they concluded that morbidity in diabetic patient is associated with indicators of lower socioeconomic status (Gulliford et al., 1998). In 2017 a cross-sectional study was done in Japan and they included 782 patients with type 2 diabetes aged 20–40 years, and they concluded that a low SES will increase the chance of type 2 diabetes complications (Funakoshi et al., 2017). A study was conducted in the United States, South Carolina, and they concluded that there is a relationship between SES and Diabetes outcome (Walker et al., 2014). Due to limited published studies that examine the social determinant among T2DM in Saudi Arabia despite the huge burden this study aims to determine the association between inequalities in key social determinants and type 2 diabetes mellitus morbidity.

2. METHODOLOGY

Study design and participants

A cross-sectional study was conducted among T2DM patients who attend Family medicine clinics at King Saud University Medical City in Riyadh. The sample size was 574, based on a single proportion equation + 10% non-response rate. The study was conducted during the period between February/2020 and May/2021.

Data collection

The Family Medicine clinics have a computerized record of every patient following up in the clinics. Patients who are eligible per our inclusion criteria (diagnosed with type two diabetes for more than one year, and aged 18 years and older) was be collected from the full list of the patients, then a sample of 574 patients was collected by simple random sampling technique. We acknowledge and recognize the ongoing pandemic issue of coronavirus disease-19 (Covid-19), and it is a limitation for our study, therefore we conducted the study via phone call interview. Every patient was interviewed via phone call, we called the patient from a dedicated number and a consent form read at the beginning of the interview for each patient. The consent form contains an explanation of the study, study objectives, duration of the participant's participation, description of the benefits, whom and how to contact for questions regarding the actual study, and the ability of the participant to withdraw at any point of the questionnaire. Then we asked for their acceptance to participate in the study. Each patient was interviewed, and we filled a validated questionnaire that was used before in published research, and the permission was taken to use the Questionnaire.

The questionnaire was translated into Arabic version by Hussain Alrikabi, an accredited National Accreditation Authority for Translation and Interpreters (NAATI) translator. The questionnaire contains demographic information and questions that focus on the past medical history of the patients. The presence of the morbidity was taken from the medical records and the Questionnaire. Variables measured: 1- Demographics 2- Cardiovascular morbidity: defined as if the patient had a self-reported or well-

documented diagnosis of Stroke, Coronary artery disease, underwent a procedure for coronary artery disease, lower limb ulcer or amputation. 3- Retinopathy: defined as if the patient has a well-documented diagnosis of retinopathy or was told by an ophthalmologist that he has retinopathy. 4- Neuropathy: defined as if the patient had a well-documented diagnosis of peripheral neuropathy or presence self-reported lack of feeling and tingling pain in legs and feet. Nephropathy was defined as if the patient had estimated glomerular filtration rate<60 ml/min/1.73m^{2}was calculated from serum creatinine using the Modification of Diet in Renal Disease (MDRD) Study equation.

Most recent glycosylated hemoglobin was recorded from the patient's records, glycemic control was categorized into controlled (HbA1c < 53 mmol/mol (< 7%)), partially controlled (HbA1c 53–63 mmol/mol (7% to < 8%)), and poorly controlled (HbA1C ≥ 64 mmol/mol (≥ 8%)) (Sonne et al., 2017). A HbA1c cut-off value of > 68 mmol/mol (≥ 9%) was also used to represent very poor control (Oglesby et al., 2006). Fasting blood glucose defined as poor glycemic control if the level above 130 mg/dL (Kassahun et al., 2016). Lipid panel classified as LDL > 2.0 mmol/L (77.3 mg/dl), triglycerides > 2.0 mmol/L (177.1 mg/dl), or HDL < 1.0 mmol/L (38.7 mg/dl) (Deed et al., 2014). Hypertension was defined if the patient has well documented diagnosis of hypertension, or by current antihypertensive treatment, or by the average of recent two reading of the blood pressure which was recorded either systolic blood pressure of <140mmHg or diastolic blood pressure of<90 mmHg (De Boer et al., 2017). Micro albuminuria is defined as an albumin/creatinine ratio of 30 to 300 mg of albumin per g of creatinine, and macroalbuminuria is defined as an albumin/creatinine ratio of more than 300 mg of albumin per g of creatinine (Chen et al., 2017). Body Mass Index (BMI) was categorized into normal (< 25.0 kg/m2), pre-obesity (25.0–29.9 kg/m2), and obesity (class I, II and II ≥ 30.0 kg/m2) as per the current World Health Organization guidelines (Al-Lawati et al., 2008).

Statistical analyses

The collected data were analyzed using the JMP software (v 16.0, JMP business unit of SAS Institute). Descriptive statistics were used to analyze the baseline data of the study participants. In addition, multivariate logistic regression was performed to assess the association between the patients' socioeconomic status and the prevalence of T2DM complications. In model one, the researchers adjusted for the age variable and the model was assessed for the general risk factors (gender, marital status, educational level, monthly income, and most recent blood sugar measurement, duration of diabetes, main work, and living region). In model two, the model was adjusted for all risk factors including the participants' demographic factors. The third model included duration of diabetes + most recent fasting blood sugar measurement (mg/dl) as intermediate variables in the causal relationship between the patients' socioeconomic variables and T2DM complications.

3. RESULT

The results presented in Table 1 shows the sociodemographic characteristics of the study participants. The mean age of the participants was (57.93±10.20) years. The study comprised of an equal number of both genders (n=287) for each one. Exploring the marital status of the study participants showed that married patients were representing the highest category (80.1%, n=460), followed by widowed patients (12.7%, n=73). In the third rank was the divorced patients (5.4%, n=31) and in the final rank was the single patients, which constituted 1.7% (n=10). Categorizing the patients based on the educational level revealed that patients holding university degree constituted 29.6% (n=170), whereas illiterate patients comprised 20.4% (n=117), tertiary school patients (19.9%, n=114), and primary school category represented 17.4% (n=100). The least represented category was the intermediate school participants as they constituted 12.7% (n=73). The majority of the participants were Saudi patients (93.2%, n=535), whereas non-Saudi patients comprised 6.8% (n=39). Investigating the participants' main work revealed homemakers and housewives represented 36.9% (n=212), followed by retired participants (31.4%, n=180). In addition, working participants constituted 27.9% (n=160). The least represented categories were those who are not working and either able to work and unable to work as they constituted 2.1% (n=12) and 1.7% (n=10).

Moreover, the results showed that 28% of the study participants were getting more than 12000 SAR. In addition, about 25.85% (n=148) of the study participants were getting less than 3000 SAR monthly. Moreover, the patients who got 3001 to 6000 constituted 21.4% (n=123), whereas 15.9% (n=91) were categorized as having a monthly income ranging between 6001 and 9000 SAR. Finally, the least represented category were those who had 9001 to 12000 SAR monthly, which constituted 8.9% (n=51). The majority of the study participants were living in a Villa (71.1%, n=481), whereas 14.1% (n=81) were living on a floor in a villa or a building. The mean range of housing units was (2.82±0.97). The mean duration of DM among the study participants was (14.74±8.9) years. The results showed that 58.5% (n=336) of the study participants were following up for diabetes every three months, whereas 32.4% (n=186) were following every six months. In addition, the majority of the study participants (82.8%, n=475) were following in public

hospitals, whereas 13.8% (n=79) were following at diabetic centers. The results related to the type of management revealed that oral and insulin management was adopted by 52.6% (n=302), 40.2% (n=231) used oral tablets, 6.3% (n=36 used insulin to manage DM, and 0.9% (n=5) were on diet only.

Table 1 socio-demographic characteristics

Variable	M ±SD	F (%)
Age	57.93±10.20	
Gender		
Female		287(50)
Male		287(50)
Marital Status		
Single		10 (1.7)
Married		460 (80.1)
Divorced		31 (5.4)
Widowed		73 (12.7)
Educational level		
illiterate		117 (20.4)
Primary school		100 (17.4)
Intermediate school		73 (12.7)
Tertiary school		114 (19.9)
University degree		170 (29.6)
Nationality		
Saudi		535 (93.2)
Non-Saudi		39 (6.8)
Main Work		
Working		160 (27.9)
Not working (Able to work)		12 (2.1)
Not working (unable to work)		10 (1.7)
Homemaker (Housewife)		212 (36.9)
Retired		180 (31.4)
Monthly income		
≤ 3000 Saudi Riyals		148 (25.8)
3001 - 6000		123 (21.4)
6001 - 9000		91 (15.9)
9001 - 12000		51 (8.9)
≥ 12000		161 (28)
Living region		
Inside Riyadh		485 (84.5)
Outside Riyadh		89 (15.5)
Housing Unit		
Traditional house		35 (6.1)
A floor in A villa		35 (6.1)
A floor in a traditional house		12 (2.1)

Variable	M ±SD	F (%)
Villa		408 (71.1)
Apartment		81 (14.1)
Other		3 (5)
Duration of DM (Years)	14.74±8.9	--------
How frequent are you following up for diabetes?		
Monthly		15 (2.6)
Every 2 months		6 (1.0)
Every 3 months		336 (58.5)
Every 6 months		186 (32.4)
Every 1 year		18 (3.1)
Irregular		13 (2.3)
Where do you usually follow up for your diabetes?		
Primary healthcare center		9 (1.6)
Diabetic center		79 (13.8)
Public hospital		475 (82.8)
Private centers		11 (1.9)
Type of management		
Diet only		5(0.9)
Oral tablets		231 (40.2)
Insulin		36 (6.3)
Oral and Insulin		302 (52.6)

Table 2 shows the clinical characteristics of the study participants. The results revealed that 91.8% (n=527) have self-monitoring blood glucose device at home. However, 35.4% (n=203) and 31.7% (n=182) were measuring blood glucose levels 2-6 times a week and daily (once or more), respectively. A total of 65.9% (n=378) were hypertensive, 79.3% (n=455) were having Dyslipidemia. Moreover, the results indicated that 10.8% (n=62) had heart disease or coronary artery disease, and 5.9% (n=34) had a stroke before.

The results showed that 13.9% (n=80) of the patients were having nephropathy, whereas 26.7% (n=153) having retinopathy. Moreover, the results indicated that 36.4% (n=209) had peripheral neuropathy. However, only 3.5% (n=20) had unhealed wound or foot ulcers and a lower percentage (0.7%, n=4) had an amputation to lower extremities. Finally, the results showed that the majority of the study participants never smoked (82.9%, n=476).

The results related to of most recent blood tests showed that the mean value of most recent fasting blood sugar was (9.04±3.466), haemoglobin A1c (8.65±1.92), serum creatinine (81.68±53.27mg/dl), albumin/creatinine ratio (156.96±567.1), eGFR (85.97±27.3 ml/min), LDL (2.33±0.89), HDL (1.23±0.37), and triglycerides (1.75±1.14).Finally, the results showed that the mean BMI scores were (31.48±5.93). The majority of the participants (58.5, n=336) were within the obese category. About 30% (n=172) were within the overweight category (Figure 1).

Table 2 Clinical characteristics of the study participants.

Variable	M ±SD	F (%)
Do you have a self-monitoring blood glucose device at home?		
Yes		527(91.8)
No		47(8.2)
How often do you measure your blood glucose at home over the last month?		
Daily (once or more)		182 (31.7)
2 – 6 times every week		203 (35.4)
Once weekly		53 (9.2)

Variable	M ±SD	F (%)
1 – 2 times a month		59 (10.3)
Did not use it		77 (13.4)
Presence of:		
Hypertension		378 (65.9)
Dyslipidemia		455 (79.3)
heart disease or coronary artery disease		62 (10.8)
Stroke		34 (5.9)
Nephropathy		80 (14.3)
Retinopathy		153 (26.7)
Peripheral neuropathy		209 (36.4)
Unhealed wound or ulcer in your feet		20 (3.5)
Do you have any amputation to your lower extremities?		
Yes		4 (0.7)
No		570 (99.3)
Do you or did you smoke any tobacco products such as cigarettes or Shisha (water pipe)?		
No, Never smoked		476 (82.9)
Yes, in the past (more than 1 month)		51 (8.9)
Yes, currently smoking		47 (8.2)
Average of most two recent reading of blood pressure		
Systolic	136.6±16.4	
Diastolic	74±9.6	
Most recent fasting blood sugar measurement (mmol/L)		
Normal		180 (31.7)
Poor glycemic control		392 (68.3)
Most recent haemoglobin A1c (HbA1c) measurement (%)		
Controlled HbA1c	8.65±1.92	110 (19.2)
Partially controlled HbA1c		127 (22.1)
Poorly controlled HbA1c		337 (58.7)
Most recent serum creatinine reading (mg/dl)		
Normal	81.68±53.27	521 (90.8)
Elevated		53 (9.2)
Most recent albumin/creatinine ratio test (mg/gm)		
Normal	156.96±567.1	364 (63.4)
microalbuminuria		165 (28.7)
macroalbuminuria		45 (7.8)
Most recent eGFR (ml/min)		
<60	85.97±27.3	80 (14.3)
≥ 60		492 (85.7)
LDL (mmol/L)		
≤ 2%	2.33±0.89	236 (41.1)
> 2%		338 (58.9)
HDL (mmol/L)		
Less than 1 mmol/L	1.23±0.37	180 (31.4)
≥ 1 mmol/L		394 (68.6)
Triglycerides (mmol/L)		
≤ 2 mmol/L	1.75±1.14	423 (73.7)
> 2 mmol/L		151 (26.3)
Patient BMI	31.48±5.93	

Table 3 shows the Odd Ratios (ORs) for nephropathy based on the SES variables. In model one, which was adjusted for participants' age, it was found that the odds of having nephropathy was greater among females (OR 1.22, CI 95% 1.10-1.38), or divorced or widowed patients (OR 2.31, CI 95% 2.18-3.96), or patients having secondary school or less (OR 1.10, CI 95% 1.01-2.63), or patients having a monthly income more than 6000 SAR (OR 2.53, CI 95% 0.76-3.07), or patients having DM duration more than 15 years (OR 2.55, CI 95% 0.71-3.48), or retired or not working patients (OR 2.51, CI 95% 1.73-4.26), and those who were living outside Riyadh (OR 2.15, CI 95% 1.41-3.70). In model two, it was found that the odds of having nephropathy was greater among females

(OR 1.36, CI 95% 0.86-3.51), or divorced or widowed patients (OR 2.49, CI 95% 2.34-3.10), or patients having secondary school certificate or less (OR 1.39, CI 95% 1.08-3.24), or patients with monthly income more than 6000 SAR (OR 2.69, CI 95% 1.08-3.58), or patients with DM duration higher than 15 years (OR 2.72, CI 95% 1.47-3.05), or retired or not working patients (OR 2.78, CI 95% 1.91-3.75), or patients living outside Riyadh (OR 2.36, CI 95% 0.76-2.61).

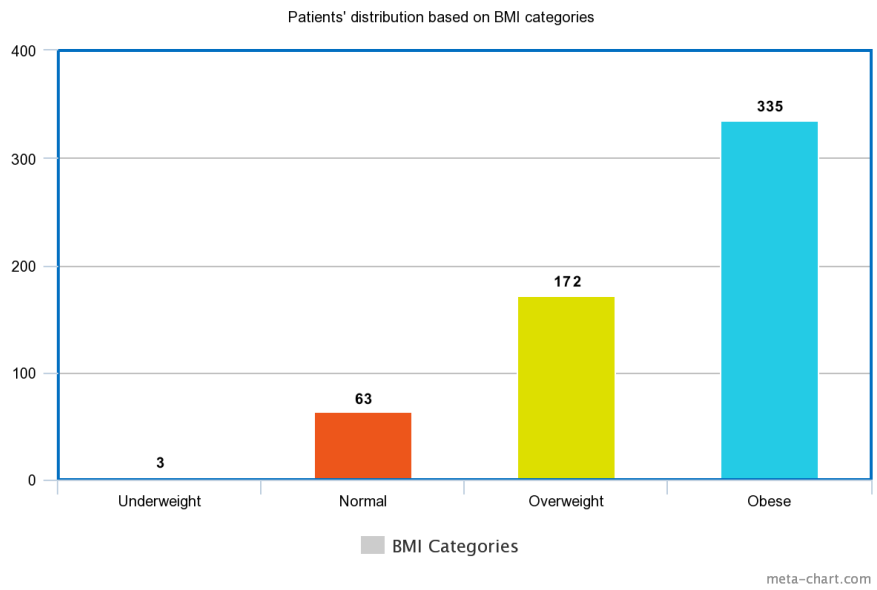

Figure 1 Patients' distribution based on BMI categories

In the third model, it was found that the odds of having nephropathy was greater among females (OR 1.64, CI 95% 1.04-4.09), or divorced or widowed patients (OR 2.77, CI 95% 2.37-3.33), or patients with secondary school education or less (OR 1.84, CI 95% 1.45-3.16), or patients with an income more than 6000 SAR (OR 2.91, CI 95% 1.51-3.61), or patients with DM duration more than 15 years (OR 2.91, CI 95% 1.78-4.92), or retired or not working patients (OR 3.11, CI 95% 1.41-4.08), or patients living outside Riyadh (OR 2.49, CI 95% 1.73-3.18).

Table 3 Multivariate logistic regression analysis for SES and nephropathy

	n	**nephropathy (n)**	**Prevalence nephropathy (%)**	**Model 1**		**Model 2**		**Model 3**	
				OR	95% CI	OR	95% CI	OR	95% CI
Gender									
Male	287	36	12.5	1.00		1.00		1.00	
Female	287	44	15.3	1.22	(1.10-1.38)	1.36	(0.86-3.51)	1.64	(1.04-4.09)
Marital status									
Single	10	1	10	1.00		1.00		1.00	
Married	460	58	12.6	1.08	(1.01-3.16)	1.19	(0.83-3.52)	1.49	(0.56-2.73)
Divorced or widowed	104	21	20.2	2.31	(2.18-3.96)	2.49	(2.34-3.10)	2.77	(2.37-3.33)
Educational level									
Illiterate	117	21	18	1.00		1.00		1.00	
Secondary school or less	287	44	15.3	1.10	(1.01-2.63)	1.39	(1.08-3.24)	1.84	(1.45-3.16)
University education	170	15	8.8	1.05	(0.59-2.26)	1.16	(0.91-3.01)	1.18	(0.86-2.63)

	n	nephropathy (n)	Prevalence nephropathy (%)	Model 1		Model 2		Model 3	
				OR	95% CI	OR	95% CI	OR	95% CI
Monthly income									
≤ 3000 SAR	148	28	18.9	1.00		1.00		1.00	
3001 - 6000	214	32	15	1.47	(1.27-2.09)	1.56	(0.72-3.14)	1.89	(1.68-5.15)
More than 6000 SAR	212	20	9.4	2.53	(0.76-3.07)	2.69	(1.08-3.58)	2.91	(1.51-3.61)
Most recent fasting blood sugar measurement (mg/dl)									
Normal	182	33	18.1	1.00		1.00		1.00	
Poor glycemic control	392	47	12	2.16	(1.87-2.57)	2.34	(2.11-4.55)	2.71	(2.18-3.94)
Duration of diabetes									
Less than 6 years	119	6	5	1.00		1.00		1.00	
6 – 15 years	218	19	8.7	2.05	(1.26-3.36)	2.23	(0.59-3.73)	2.49	(1.19-3.18)
More than 15 years	237	55	23.2	2.55	(0.71-3.48)	2.72	(1.47-3.05)	2.91	(1.78-4.92)
Main Work									
Working	160	10	6.3	1.00		1.00		1.00	
Retired or not working	202	38	18.8	2.51	(1.73-4.26)	2.78	(1.91-3.75)	3.11	(1.41-4.08)
Housewife or homemaker	212	32	15.1	1.27	(1.86-2.25)	1.59	(0.71-2.08)	1.83	(1.17-4.09)
Living region									
Inside Riyadh	485	67	13.8	1.00		1.00		1.00	
Outside Riyadh	89	13	14.6	2.15	(1.41-3.70)	2.36	(0.76-2.61)	2.49	(1.73-3.18)

Model 1: Adjusted for age

Model 2: Model 1 + gender + marital status+ educational level+ monthly income + Main work

Model 3: Model two + duration of diabetes + most recent fasting blood sugar measurement (mg/dl)

Table 4 shows the Odd Ratios (ORs) for retinopathy based on the SES variables. In model one, which was adjusted for participants' age, it was found that the odds of having retinopathy was greater among females (OR 2.17, CI 95% 1.53-3.47), or married patients (OR 1.86, CI 95% 1.05-4.18), or patients having secondary school or less (OR 2.51, CI 95% 1.21-6.09), or patients having a monthly income between 3001 and 6000 SAR (OR 2.28, CI 95% 1.73-4.18), or patients having DM duration more than 15 years (OR 2.59, CI 95% 1.57-4.06), or retired or not working patients (OR 2.40, CI 95% 1.60-2.71), and those who were living outside Riyadh (OR 1.79, CI 95% 0.76-2.81). In model two, it was found that the odds of having retinopathy was greater among females (OR 2.31, CI 95% 1.39-6.11), or married patients (OR 2.11, CI 95% 0.54-2.99), or patients having secondary school certificate or less (OR 2.76, CI 95% 1.93-3.60), or patients with monthly income between 30001 and 6000 SAR (OR 2.46, CI 95% 2.39-3.81), or patients with DM duration higher than 15 years (OR 2.84, CI 95% 2.10-3.58), or retired or not working patients (OR 2.73, CI 95% 2.17-3.08), or patients living outside Riyadh (OR 1.93, CI 95% 1.53-3.07).

In the third model, it was found that the odds of having retinopathy was greater among females (OR 2.54, CI 95% 2.01-3.16), or married patients (OR 2.48, CI 95% 1.16-3.25), or patients with secondary school education or less (OR 3.12, CI 95% 1.63-7.19), or patients with an income between 3001 and 6000 SAR (OR 2.81, CI 95% 1.50-3.09), or patients with DM duration more than 15 years (OR 2.93, CI 95% 2.06-8.19), or retired or not working patients (OR 3.27, CI 95% 2.51-4.63), or patients living outside Riyadh (OR 2.06, CI 95% 0.92-2.86).

Table 4 Multivariate logistic regression analysis for SES and retinopathy

	n	retinopathy (n)	Prevalence retinopathy (%)	Model 1		Model 2		Model 3	
				OR	95% CI	OR	95% CI	OR	95% CI
Gender									
Male	287	63	22	1.00		1.00		1.00	
Female	287	90	31.4	2.17	(1.53-3.47)	2.31	(1.39-6.11)	2.54	(2.01-3.16)
Marital status									
Single	10	1	10	1.00		1.00		1.00	
Married	460	116	25.2	1.86	(1.05-4.18)	2.11	(0.54-2.99)	2.48	(1.16-3.25)
Divorced or widowed	104	36	34.6	1.27	(1.06-1.47)	1.78	(0.93-2.11)	2.13	(1.76-2.69)
Educational level									
illiterate	117	41	35	1.00		1.00		1.00	
Secondary school or less	287	76	26.5	2.51	(1.21-6.09)	2.76	(1.93-3.60)	3.12	(1.63-7.19)
University education	170	36	21.2	1.48	(1.10-2.63)	1.61	(1.03-2.55)	1.88	(0.91-2.81)
Monthly income									
≤ 3000 SAR	148	54	36.5	1.00		1.00		1.00	
3001 - 6000	214	59	27.6	2.28	(1.73-4.18)	2.46	(2.39-3.81)	2.81	(1.50-3.09)
More than 6000 SAR	212	40	18.9	1.14	(0.77-2.08)	1.42	(1.18-3.29)	1.84	(1.07-2.16)
Most recent fasting blood sugar measurement (mg/dl)									
Normal	182	48	26.3	1.00		1.00		1.00	
Poor glycemic control	392	105	26.8	2.51	(1.36-3.30)	2.91	(2.18-3.57)	2.98	(2.50-4.12)
Duration of diabetes									
Less than 6 years	119	12	10.1	1.00		1.00		1.00	
6 – 15 years	218	50	23	1.88	(1.31-2.64)	2.16	(1.94-3.57)	2.69	(2.01-6.19)
More than 15 years	237	91	38.4	2.59	(1.57-4.06)	2.84	(2.10-3.58)	2.93	(2.06-8.19)
Main Work									
Working	160	32	20	1.00		1.00		1.00	
Retired or not working	202	48	23.8	2.40	(1.60-2.71)	2.73	(2.17-3.08)	3.27	(2.51-4.63)
Housewife or homemaker	212	73	34.4	1.64	(0.59-2.25)	1.38	(1.16-2.76)	1.81	(0.93-2.35)
Living region									
Inside Riyadh	485	121	25	1.00		1.00		1.00	
Outside Riyadh	89	32	36	1.79	(0.76-2.81)	1.93	(1.53-3.07)	2.06	(0.92-2.86)

Model 1: Adjusted for age

Model 2: Model 1 + gender + marital status+ educational level+ monthly income + Main work

Model 3: Model two + duration of diabetes + most recent fasting blood sugar measurement (mg/dl)

Table 5 Multivariate logistic regression analysis for SES and peripheral neuropathy

	n	peripheral neuropathy (n)	Prevalence peripheral neuropathy (%)	Model 1		Model 2		Model 3	
				OR	95% CI	OR	95% CI	OR	95% CI
Gender									
Male	287	88	30.7	1.00		1.00		1.00	
Female	287	121	42.2	2.18	(1.83-3.19)	2.37	(1.93-2.97)	2.70	(2.09-5.27)
Marital status									
Single	10	2	20	1.00		1.00		1.00	
Married	460	166	36.1	1.64	(0.79-3.28)	2.14	(1.79-4.19)	2.94	(1.50-3.61)
Divorced or widowed	104	41	39.4	2.14	(1.61-2.98)	2.51	(2.38-3.80)	2.89	(2.07-3.57)
Educational level									
Illiterate	117	49	41.9	1.00		1.00		1.00	
Secondary school or less	287	111	38.7	2.55	(1.84-2.73)	2.94	(1.62-3.77)	2.91	(1.16-5.21)
University education	170	49	28.8	1.61	(1.08-2.69)	1.54	(0.76-2.84)	1.74	(1.12-3.58)
Monthly income									
≤ 3000 SAR	148	60	40.5	1.00		1.00		1.00	
3001 - 6000	214	90	42.1	1.84	(0.94-2.34)	1.90	(1.43-2.26)	2.28	(1.86-3.07)
More than 6000 SAR	212	59	27.8	2.01	(1.51-2.64)	2.18	(1.49-3.37)	2.29	(2.13-3.41)
Most recent fasting blood sugar measurement (mg/dl)									
Normal	182	67	36.8	1.00		1.00		1.00	
Poor glycemic control	392	142	36.2	1.68	(1.42-2.45)	2.14	(1.95-3.18)	2.65	(1.87-2.90)
Duration of diabetes									
Less than 6 years	119	30	25.2	1.00		1.00		1.00	
6 – 15 years	218	80	36.7	2.34	(1.79-3.24)	2.46	(2.01-6.18)	2.84	(1.53-4.07)
More than 15 years	237	99	41.8	1.93	(0.79-2.29)	2.55	(1.73-4.33)	2.88	(1.17-3.51)
Main Work									
Working	160	48	30	1.00		1.00		1.00	
Retired or not working	202	67	33.2	2.53	(2.14-3.64)	2.82	(2.41-3.07)	3.51	(2.71-5.32)
Housewife or homemaker	212	94	44.3	1.08	(0.71-3.04)	1.21	(0.59-2.26)	1.37	(0.73-2.51)
Living region									
Inside Riyadh	485	179	37	1.00		1.00		1.00	
Outside Riyadh	89	30	33.7	1.71	(1.33-2.83)	2.10	(1.70-4.36)	2.38	(0.91-6.82)

Model 1: Adjusted for age

Model 2: Model 1 + gender + marital status+ educational level+ monthly income + Main work

Model 3: Model two + duration of diabetes + Most recent fasting blood sugar measurement (mg/dl)

Table 5 shows the Odd Ratios (ORs) for peripheral neuropathy based on the SES variables. In model one, which was adjusted for participants' age, it was found that the odds of having peripheral neuropathy was greater among females (OR 2.18, CI 95% 1.83-3.19), or Divorced or widowed patients (OR 2.14, CI 95% 1.61-2.98), or patients having secondary school or less (OR 2.55, CI 95% 1.84-2.73), or patients having a monthly income more than 6000 SAR (OR 2.01, CI 95% 1.51-2.64), or patients having DM duration between 6 and 15 years (OR 2.34, CI 95% 1.79-3.24), or unemployed patients (OR 2.43, CI 95% 1.63-5.47), and those who were living outside Riyadh (OR 1.71, CI 95% 1.33-2.83).

In model two, it was found that the odds of having peripheral neuropathy was greater among females (OR 2.37, CI 95% 1.93-2.97), or divorced or widowed patients (OR 2.51, CI 95% 2.38-3.80), or patients having secondary school certificate or less (OR 2.94, CI 95% 1.62-3.77), or patients with monthly income more than 6000 SAR (OR 2.18, CI 95% 1.49-3.37), or patients with DM duration higher than 15 years (OR 2.55, CI 95% 1.73-4.33), or unemployed patients (OR 2.71, CI 95% 1.93-2.96), or patients living outside Riyadh (OR 2.10, CI 95% 1.70-4.36). In the third model, it was found that the odds of having peripheral neuropathy was greater among females (OR 2.70, CI 95% 2.09-5.27), or married patients (OR 2.94, CI 95% 1.50-3.61), or patients with secondary school education or less (OR 2.91, CI 95% 1.16-5.21), or patients with an income more than 6000 SAR (OR 2.29, CI 95% 2.13-3.41), or patients with DM duration more than 15 years (OR 2.88, CI 95% 1.17-3.51), or retired or not working patients (OR 3.51, CI 95% 2.71-5.32), or patients living outside Riyadh (OR 2.38, CI 95% 0.91-6.82).

4. DISCUSSION

To the best of the researchers' knowledge, this is one of the few studies in Saudi Arabia that investigated the socioeconomic inequalities among type 2 diabetes mellitus (T2DM) patients and its association to T2DM morbidity. The results of the present study showed that the odds of nephropathy were higher among females, divorced or widowed patients, less educated patients, high-income patients, poor glycemic control, higher duration of DM, being retired or unemployed and living outside Riyadh region. This might be attributed to that nephropathy is a deterioration event results as a complication after a long duration of DM. Therefore, kidney deterioration occurs. It was reported by Zhang et al., (2020), who reported that nephropathy is significantly associated with T2DM, higher in the male-dominated studies than in the female-dominated studies, which is contradictory to the finding of the present study. The researchers attributed that association of socioeconomic factors to insufficient resources and lack of access to healthcare services, especially for people living in rural areas. In addition, it was reported by Lee, widowed DM patients and low education DM patients were at higher risk of nephropathy since they have lower diabetic nephropathy screening rates (Lee, 2018).

On the other hand, results related to retinopathy complication among T2DM and its socioeconomic factors determinants revealed that retinopathy risk was higher among females, married, less educated patients, medium income, poor glycemic control, higher duration of DM, being retired or unemployed, and living outside Riyadh region. These results could be referred to that retinopathy is a complication that depends mainly, as other complications, on self-care activities and regular checkups that limit the progress of the disease and its complications. Low socioeconomic determinants are significantly limiting T2DM patient's access to healthcare services and limit their acquired knowledge regarding adherence to self-care activities. These results are consistent with the findings of Hussain et al., (2013), who reported higher retinopathy risk among T2DM patients having higher DM duration. However, Hussain et al., (2013) reported that males were at higher risk of retinopathy than females, which is contradictory to the findings of the present study. In addition, these results are consistent with the findings reported by Alvarez-Ramos et al., (2020) who found that DM patients residing in less deprived zones, and lower socioeconomic levels were at higher risk of nephropathy. A systematic review was done by Grintsova et al., (2014) which showed patients with lower socioeconomic status are often associated with a higher risk of microvascular complication including retinopathy.

Finally, it was found that; females, married, low educated, higher income, poorly glycemic controlled, retired or not working and T2DM patients living outside Riyadh region were at higher risk of neuropathy as a complication of T2DM. The researchers referred these findings to the low socioeconomic status of these categories of T2DM patients, which puts them at higher risk because of their low level of knowledge and low self-care and self-management practices as a result of their knowledge level. This result was evidenced by Amelia et al., (2019) who reported that the duration of diabetes is a significant risk factor of neuropathy complication. In addition, the results of this study are supported by the findings reported by Jasmine et al., (2020) who found that low educational level, poor glycemic control and higher duration of DM are significant risk factors of diabetic neuropathy.

The present study provided research-based evidence regarding the social inequalities and the association of socioeconomic factors to the complications of T2DM among Saudi T2DM patients. Since T2DM complications cause a significant decline in the quality of life among T2DM patients and increase the mortality and morbidity rate, this study provides baseline data for healthcare stakeholders and decision-makers to develop and design action plans that aim to improve healthcare access, knowledge, awareness

and practice of self-care management and self-care activities among the at high-risk groups, specifically females, low educated people, and T2DM who have poorer glycemic control. In addition, the present study highlights the geographical areas of patients living in Riyadh region, and outside Riyadh region, that need an urgent improvement of the healthcare services provided for T2DM patients. Furthermore, the present study pays the attention of the healthcare decision-makers to adopt health equity measures to ensure the delivery of high-quality healthcare services for chronic diseases patients in general, and T2DM patients in particular.

The present study has several strength points, including its focus on different complications of T2DM, including different socioeconomic determinants and the use of objective data in the research process. However, there are different limitations of the study, such as focusing on one geographical zone, which is Riyadh region, this might limit the generalizability of the study findings and require extending the study to include different geographical zones. The present study recommends conducting further studies that recruit a higher number of T2DM patients, or even conducting a nationwide study to assess the socioeconomic inequalities among T2DM patients, to provide more accurate and reliable findings based on objective national data. In addition, the present study recommends the healthcare policymakers review and reassess the delivery of the healthcare services for those who live outside Riyadh region, and away from the main hospital, in which they follow up their diabetes and ensure that all T2DM patients have equal opportunities to receive the high-quality healthcare services.

5. CONCLUSION

The present study indicated that females, lower socioeconomic determinants such as lower educational level, unemployment, poor glycemic control, higher duration of DM were significantly associated with a higher prevalence of T2DM complications. The findings of the present study impose the urgent need for action plans to ensure the appropriate delivery of healthcare services and educational interventions to T2DM patients, especially females, and low educated people.

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Ethical Approval

The study was approved by the Institutional Review Board (IRB) at King Saud University Medical City (Ref No. 20/0754/IRB) (Project No. E-20-5005).

Author Contributions

Nurah Alamro, Abdulaziz Alahmari, and Mohammed Batais designed this research, data collection, data cleaning, data analysis, and manuscript writing. Abdulhadi Alsalhi, Talal Alsaeed contributed in data collection, data cleaning, data analysis, and manuscript writing. All authors reviewed the manuscript and approved the final version.

Conflicts of interest

The authors declare that they have no conflict of interest.

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Data and materials availability

All data associated with this study are present in the paper.

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